Optical Coherence Tomography in Macular Disease

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OCT Key Points...
- Fast
- Noninvasive
- In vivo histopathology
- Change analysis
- Compliment to other studies

Principles of OCT
- “Laser-guided echography”
- Near IR laser (810 nm)
- Reflectance characteristics of intraocular structures
- Comparison to reference mirror
- Analysis of interference patterns
- 2-d & 3-d mapping of retinal & optic nerve tomography
- Time domain (standard) vs. spectral domain (SD-OCT)

“Optical Biopsy”
- Cross sectional analysis of retinal structures:
  - Sensory retina
  - RPE
  - Choroid
- Resolution of ≈ 10 microns
- In vivo analysis of histopathology

System Configuration

<table>
<thead>
<tr>
<th>Source</th>
<th>Beam Splitter</th>
<th>Detector</th>
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<tbody>
<tr>
<td>Xref</td>
<td>Xsample</td>
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<tr>
<td>No Interference</td>
<td>OCT Signal</td>
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A scan
Axial (longitudinal) measurement that gives information about depth
B scan
Series of A scans taken at different transverse points and finally reconstructed into a 2-dimensional image of tissue.

OCT incorporates both A scan and B scan, resulting in a cross-sectional image of tissue.

Image Formation
• Z axis samples tissue with 1024 datapoints over a 2 mm depth
• X-Y axis takes a sample of tissue every 5-60 microns using up to 512 datapoints

Retinal Thickness Map & B Scan

Retinal Thickness/Volume Analysis

RNFL Thickness/Average Analysis

Spectral Domain OCT
Spectral Domain OCT (HD-OCT)

- 65X faster than time domain OCT:
  - TD-OCT = 400 A scans/sec.
  - SD-OCT = 30,000 – 60, A scans/sec.
  - SS-OCT = 100,000 A scans/sec.
- Elimination of motion artifacts
- 2X resolution (4-5 microns axial resolution)
- Data cube:
  - 6mm x 6mm
  - Relief maps of ILM, RPE and overall retina
  - Image reconstruction within sampling area (2-d & 3-d)
  - Auto-centration & registration
  - Change & progression analysis (macula & RNFL)

SD-OCT Data Cube

- 6mm x 6mm box
- 200 B scans (200 A scans / B scan) = volume
- 128 B scans (512 A scans / B scan) = image quality
- 3-D interpolation of data
- Subtraction analysis of structural changes over time

Scanning the Macula

- Macular data cube:
  - 200 x 200 protocol (volumetric analysis)
  - 512 x 128 protocol (image quality)
- Raster scan:
  - High definition image

Macular Data Cube

Raster Scan

Anatomy of the Retina
56 y/o AA Woman

- S/P scleral buckle for macula-off RRD OS
- BVA:
  - 20/20 OD
  - 20/40 OS

OCT of Abnormal Fundus

- Hyper-reflective lesions
- Hypo-reflective lesions

Hyper-reflective Lesions

- Lipoprotein exudates
- Blood
- Fibrinous fluid
- Fibrous tissue
- RPE hyperplasia/hypertrophy
- NFL infarction/myelination
68 Y/O AA woman

- Prior diabetic papillopathy OD
- Melanocytoma OS

59 y/o Hispanic Man

- c/o decreased vision OD x several years
- HTN x 10 years
- BVA:
  - HM OD
  - 20/20 OS
81 y/o Caucasian Man
- c/o decreased vision OD x 24 hrs.
- H/o Hollenhorst plaque, OD several months ago
- BVA:
  - HM OD
  - 20/30 OS

40 y/o AA Woman
- BVA:
  - 20/20 OD
  - 20/20 OS
Hypo-reflective Lesions

- Serous fluid
  - Intraretinal
  - Subretinal
  - Sub RPE
- Hypopigmented lesions of RPE

53 y/o Caucasian Woman

- H/O Recent-onset metamorphopsia, OD
- Previously documented choroidal nevus
- BVA:
  - 20/20 OD
  - 20/20 OS
67 y/o Caucasian Man

• H/O degenerative myopia OU
• c/o decreased vision OS x 2-3 weeks
9 y/o AA Male

- c/o progressive vision loss, OU for several years
- BVA:
  - 20/50 OD
  - 20/40 OS

Raster Scan

- Maximal image quality – *High Def!*
- Horizontal raster = 4096 A-scans/B-scan
- Variable scan separation (0.01mm to 1.25mm)
- Variable scan length (3mm to 9mm)
46 y/o AA Man

- Blurry vision for “many years”
- h/o psychotropic drug use
- “sun gazing” in youth (30-40 min 3-4X/week)
- BVA:
  - 20/30 OD
  - 20/30 OS
Macular Change Analysis

- Change analysis within data cube / ETDRS grid
- +/- retina thickness within ETDRS grid
- Color coding of thickness change
68 y/o AA Woman

• Progressive vision loss, OD
• + diabetic macular edema

50 y/o Hispanic Woman

• C/o reduced vision OS
• H/o sarcoidosis and prior treatment for uveitis
73 y/o AA Woman

- C/o reduced vision OS
- Exam = BVO with macular edema

1 month s/p IVT Kenalog
20/40
OCT Characteristics of Common Macular Pathology

• Retinal Vascular Disease:
  1. Diabetic maculopathy
  2. Retinal vein occlusions:
     1. CVO
     2. BVO
  3. Age-related macular degeneration

• Vitreo-Macular Traction:
  1. Macular holes
  2. Epiretinal membranes/pseudo holes

Diabetic Maculopathy

• Diabetic macular edema:
  – Most common cause of visual morbidity:
    • Focal (microaneurysms)
    • Diffuse (generalized leakage from tight junction breakdown)

OCT Patterns of Diabetic Maculopathy

• Outer layer edema
  ➢ “sponge-like” edema
• Cystoid macular edema
  ➢ Cystic spaces & septae
• Serous RD
• Taught posterior hyaloid membrane (TPHM)

Pattern 1
Sponge-like Retinal Thickening
Pattern 2
Partial Thickness Cystoid Spaces

Pattern 3
Full Thickness Cystoid Spaces

S/P grid 20/100
**61 y/o AA Man**

- Complicated DME OD
- BVA OD = 20/80

*Baseline & 1 mo. S/P Ozurdex*
Pattern 5a
Taut Posterior Hyaloid Membrane (Focal)

Pattern 5b
Taut Posterior Hyaloid Membrane (Diffuse)

Pre-PPV Taut Posterior Hyaloid
Post-PPV

Retinal Vein Occlusion

- Central retinal vein occlusion
- Branch retinal vein occlusion

OCT Characteristics of Retinal Vein Occlusions

- Cystoid macular edema
- Serous RD
- Vitreo-retinal interface abnormalities
- Macular hole formation
Age-Related Macular Degeneration

• Non-exudative AMD:
  – Drusen
  – RPE hyperplasia
  – Geographic atrophy

• Exudative AMD:
  – Choroidal neovascularization:
    • Predominantly classic (>50%)
    • Minimally classic (<50%)
    • Occult (no classic component)
  – Pigment epithelial detachment
    • Serous
    • Fibrovascular
    • Hemorrhagic

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    - Hemorrhagic

OCT & Wet AMD

- Vascular ingrowth
- Serosanguinous / hemorrhagic PED
- Serosanguinous / hemorrhagic RD
- Macular edema

\[ \text{↑ Fluid} = \text{↑ Disease Activity} \]
71 y/o woman – 20/80

s/p Intravitreal Lucentis

82 y/o woman – 20/100
3 Months S/P Lucentis x 3

Pre-Tx

Post-Tx

41 y/o AA Woman

- H/o degenerative myopia
- Recent vision loss OS
Age-Related Macular Degeneration

- Non-exudative AMD:
  - Drusen
  - RPE hyperplasia
  - Geographic atrophy

- Exudative AMD:
  - Choroidal neovascularization:
    - Predominantly classic (>50%)
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  - Pigment epithelial detachment
    - Serous
    - Fibrovascular
    - Hemorrhagic
OCT Analysis of Macular Holes

- Differentiation of true holes from pseudo-holes
- Staging of macular hole formation
- Evaluation of fellow-eye vitreo-macular traction
- Determination of surgical eligibility:
  - Hole form factor
  - Cystic degeneration of adjacent retina
  - Quantification of subretinal fluid

Staging of Macular Holes

- Stage 1: Foveolar detachment with loss of foveal depression
  - 1A = yellow spot
  - 1B = yellow halo
- Stage 2: Full-thickness defect:
  - Eccentric to fovea
  - Horseshoe-shaped
- Stage 3: Full-thickness defect:
  - Round with foveal centration
  - "bread crumbs" on RPE
  - Attached vitreous
- Stage 4: Full-thickness defect:
  - Same findings as stage 3 but with PVD
Stage 1
- Yellow spot / donut
- Loss of foveal depression
- Foveolar detachment

Stage 2
- Full thickness defect
- Crescent / horseshoe shaped
- Eccentric to foveal center

Stage 3 (c/o PVD) & 4 (c PVD)
- Central full-thickness defect
- Cuff of SRF
- Cystic retinal changes
- Superficial RPE excrescences
84 y/o Caucasian Man

- Referred by his optometrist for recent vision loss OD owing to AMD
- BVA:
  - 20/400 OD
  - 20/50 OS
Vitrectomy for Macular Holes

• Removal of vitreous and “abnormal” tractional membrane
• Expandable gas tamponade
• Re-apposition of retinal tissue

62 y/o AA Man

• C/o decreased vision, OD x 2 weeks
• BVA:
  – 20/100 OD
  – 20/20 OS

3 Months S/P PPV

• BVA:
  – 20/40 OD (cataract)
  – 20/20 OS

58 y/o AA Woman

• C/o decreased vision, OS x 5-6 weeks
• BVA:
  – 20/20 OD
  – 20/400 OS
Epiretinal Membranes
- Grade 0: cellophane maculopathy
- Grade 1: crinkled cellophane maculopathy
- Grade 2: macular pucker
  - With macular edema
  - Without macular edema

OCT Classification of Epiretinal Membranes
- Separated from inner retinal surface
- Globally adherent
66 y/o Woman

- Progressive vision loss, OD
- BVA:
  - 20/200 OD
  - 20/20 OS
Macular Pseudo-holes

- Good vision (20/25)
- Ovoid dehiscence
- Perifoveal vascular straightening
- Normal retinal tissue at base / normal central foveal thickness
- Centripetal contraction of ERM
  - Narrowing of foveal pit
  - *Acute slope* to hole margin

Lamellar Macular Defects

- Macular pseudo-holes
- Lamellar macular holes
- Foveal pseudo-cysts
Lamellar Macular Holes

- “Aborted” macular hole formation
- Mild-moderate visual impairment (20/40)
- Decreased central foveal thickness
- Inner-layer defects with bilobulated “cystic cleft” (OPL/ONL)
- With/without ERM


76 y/o AA Woman

- Blurry vision OD x several years
- BVA:
  - 20/25 OD
  - 20/20 OS

F/U x 2 years

- BVA:
  - 20/25 OD
  - 20/20 OS
63 y/o Hispanic Woman

- Blurry vision OS x several months
- BVA:
  - 20/20 OD
  - 20/30 OS
**Foveal Pseudo-Cyst**

Vitreomacular Adhesion

**Vitreomacular Traction Syndrome**

- Abnormal vitreoretinal adhesion of undetermined etiology
- F > M
- Sixth to seventh decade
- Fibroglial proliferation with incomplete posterior vitreous separation (?)
- Variable progression / spontaneous resolution
- Cystic/schisis changes on OCT


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**57 y/o Caucasian Woman**

- Recent onset blurred vision OD
- BVA:
  - 20/30 OD
  - 20/20 OS
Follow-up x 3 mos: VA = 20/20

74 y/o Caucasian Woman

- H/O slowly progressive vision loss, OU
- BVA:
  - 20/60 OD
  - 20/40 OS
**OCT Key Points...**

- Fast
- Noninvasive
- In vivo histopathology
- Change analysis
- Compliment to other studies

Thank you!